

TECHNICAL REPORT BRL-TR-3319

# BRL

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## TIME ZERO TRIGGERING SYSTEM

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MARCH 1992

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13. ABSTRACT (Maximum 200 words)  Muzzle radiography is one of a number of investigative tools that are used to study projectile behavior at or near the muzzle of the gun tube. These instrumentation systems require an accurate and reliable reference as a trigger for the instrumentation. Many weapon systems from small arms to tank guns produce a characteristic blast pressure signature when the projectile exits the gun. This report describes a triggering system developed at the Ballistic Research Laboratory (BRL) that uses this characteristic blast pressure signature to provide an accurate, reliable, and repeatable reference trigger for instrumentation.				
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## ACKNOWLEDGMENTS

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## 1. INTRODUCTION

Muzzle radiography is an important investigative tool in the study of projectile behavior. X-ray instrumentation is used to study the structural integrity, the sabot separation, and the tip-off behavior of the projectile as it leaves the muzzle of the gun. The most important and most difficult aspect of near-muzzle radiography is obtaining a reliable trigger for the x-ray instrumentation. The trigger must be consistent from round to round and activated as close to the projectile muzzle exit as possible. This report describes a Time-Zero triggering system that combines a pressure transducer near the muzzle of the gun and a Ballistic Research Laboratory (BRL) designed electronic time delay instrument to provide accurate and consistent start pulses for near muzzle radiography. This is accomplished without altering the weapon and without interfering with the projectile. This system may be used with both small- and large-caliber weapon systems.

## 2. DISCUSSION OF PRIOR ART

Over the past 30 years, there have been numerous attempts to provide a reliable ballistic trigger. Described in the following are three primary techniques used to date:

- (1) Delayed Electrical Firing Pulse. With this method, the relay that fired the gun also triggered the instrumentation. Safety requirements demanded that the trigger pulse be isolated electrically from the firing pulse to prevent accidental firing of the weapon. The isolation was accomplished with a parallel-operated relay. This method was inconsistent due to actuation of the relays and the variables associated with the burning rate of the gun powder.
- (2) Muzzle Break Wire. A wire installed across the muzzle of the gun formed part of a make or break circuit. The exit of the projectile breaks the wire, and a trigger pulse is generated by an associated circuit. Large-caliber, high-velocity projectiles produce a precursor shock that would either stretch the wire or break it prematurely. The result is a wide and unpredictable range in trigger times.

- (3) Muzzle Flash Detector. An infrared photo-detecting system detects the flash associated with the burning gun gases and triggers as the projectile exits the gun. The sensitivity of this system varies with ambient light level. A leaking projectile obturator would produce an early trigger.

Other methods include the use of pressure gages mounted near the muzzle end of the gun tube which requires a modification to the weapon or laser systems which detect the passage of the projectile through a laser beam as it exits the muzzle. Neither of these methods have provided a consistent triggering pulse to use with muzzle x-ray instrumentation.

In the study of the interaction between sabot separation and projectile flight behavior, it is required that a series of x-rays be taken in close proximity to the muzzle. Since near-muzzle film size is approximately 1.2 times the projectile length at higher velocities, this system could only tolerate a triggering error of approximately 25  $\mu$ s. Furthermore, a triggering system was needed which would not alter the weapon nor interfere with the flight of the projectile. This system should trigger on the precursor shock to allow the study of the projectile exiting the muzzle or trigger on the propelling pressure shock so the near-muzzle flight/sabot separation could be studied. The methods described previously could not meet these requirements. Therefore, a highly accurate and reliable triggering system needed to be developed.

### 3. TIME-ZERO TRIGGERING SYSTEM

As stated previously, the Time-Zero triggering system consists of one pressure probe which incorporates a pressure transducer, a specialized electronic delay circuit, and a trigger generator designed to operate in conjunction with the pressure transducer.

3.1 Pressure Probe. A pressure gage is mounted in a probe just behind the muzzle end of the gun tube. This is illustrated in Figure 1. The probe is usually not mounted on the weapon but is placed on a tripod near the tube and is designed to pivot out and away from the recoiling gun tube to prevent damage.

The pressure probe is designed to measure the near-field blast pressures associated with the firing of the weapon. These blast pressures are characteristic signatures associated with

the length of the gun tube and projectile velocity. Figure 2 shows a typical pressure probe voltage vs. time profile for a 25-mm projectile. As indicated in Figure 2, there are two voltage peaks associated with the blast profile. The first peak is produced by the precursor shock. The second pulse is produced by the main shock as the projectile exits the gun tube. As a rule, the second peak is larger in amplitude than the first; however, this is not always the case.

The pressure signature for a given weapon system is consistent and characteristic of the weapon system. Figure 3 shows a plot of precursor and main peak pressures as a function of velocity for a 120-mm weapon system. The time interval between the precursor shock and the main shock is a function of the length of the gun tube and the projectile velocity. An empirical relationship for the ratio of the time interval to the tube length and the projectile velocity is shown in Figure 4. For a given velocity, the time interval between pulses can be predicted by multiplying the corresponding value of the ratio by the tube length. The curve in Figure 4 was generated from actual test data using a variety of types and calibers of projectiles.

The voltage peak produced by the passage of the main shock past the pressure gage is the desirable trigger source. A problem arises when the precursor pulse is larger in amplitude than the main shock pulse. In addition, occasional noise in the system occurs between the two peaks which could produce a false trigger.

**3.2 Time-Zero Instrument.** A block diagram of the electronics is shown in Figure 5. The circuit generally works as follows. The output of the pressure transducer is connected to the input of the Time-Zero box and conditioned when necessary. The output of the signal conditioner is connected to two parallel threshold detection circuits. Initially, both channels are disabled until the operator manually enables channel 1. The detection of the precursor shock by channel 1 starts an internal time delay clock. The length of this delay is preset and is determined with the help of Figure 4. At the end of this preset delay time, channel 2 is enabled. Detection of the first threshold level after enabling produces an output pulse that is used for triggering an x-ray or other instrumentation. If threshold values and time delays are set correctly, this output pulse is in synchronization with the occurrence of the main blast pressure pulse.

The Time-Zero box features variable input gain and multiple output trigger pulses. Threshold detection levels are set from the front panel. An output pulse is provided at the preset time delay, which allows the unit to act as a straight delay generator. Other features include front panel clock rate selectability, display readouts of preset time delay, total interval time, and clock overflow indication. Time resolution varies from microseconds to milliseconds, depending upon the clock rate selected.

Figure 6 shows a photograph of the Time-Zero instrument that was designed and constructed at the BRL. This instrument takes advantage of the characteristic signatures observed at the pressure probe. The Time-Zero box is a specialized delay generator designed to produce an output trigger pulse in synchronization with the occurrence of the main shock pressure pulse. It works over a wide range of input signatures, even when the precursor shock is higher in amplitude than the main peak or when there is high-amplitude noise in the interval between the two peaks.

#### 4. CONCLUSIONS

The Time-Zero triggering system described in this report has been tested and has been in operation at BRL ranges for several years. It has proven to be a very reliable and accurate method of obtaining trigger pulses for radiographic instrumentation and for other instrumentation systems as well. BRL has constructed and supplied Time-Zero instrumentation boxes for the Combat Systems Test Activity (CSTA), at Aberdeen Proving Ground, MD, and to the Sandia National Laboratories in Albuquerque, NM, for use in their test ranges.

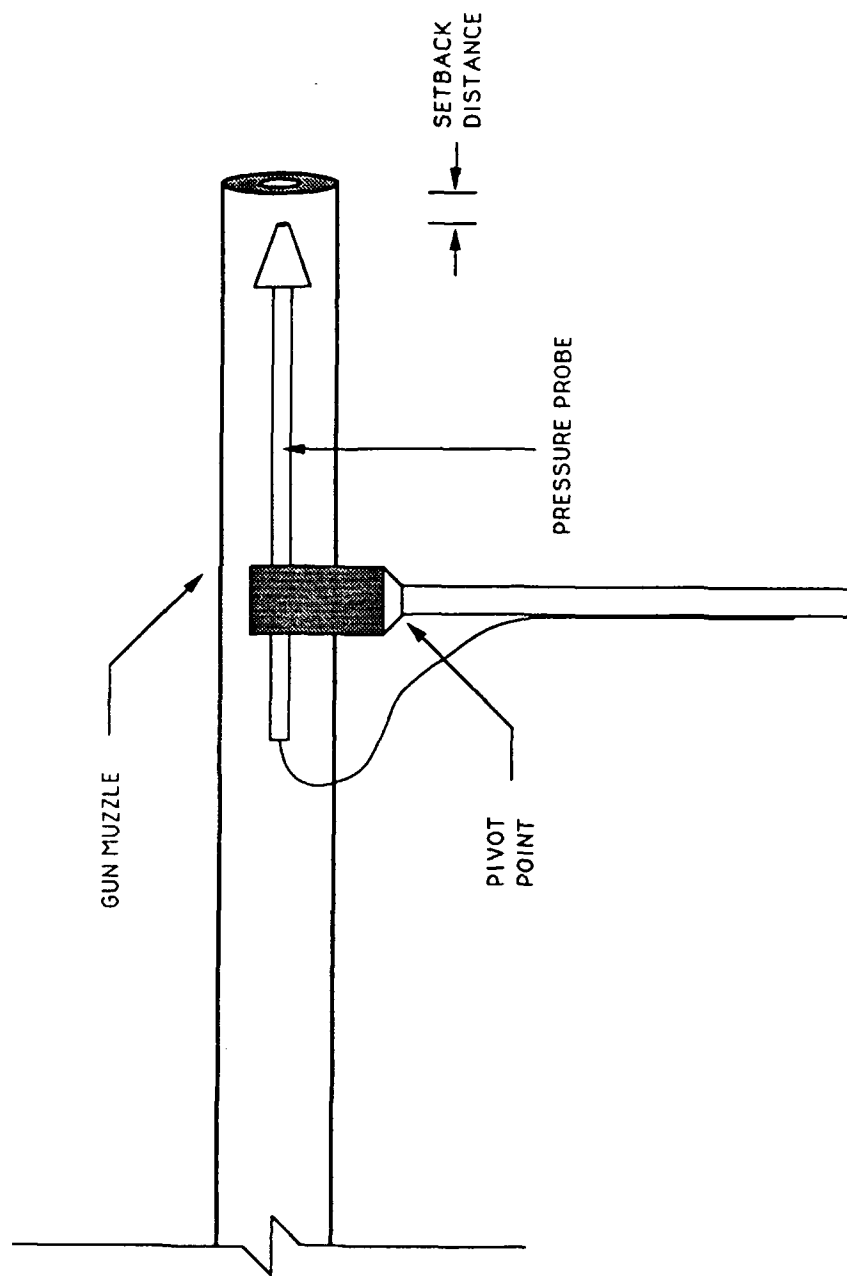


Figure 1. Mounting Location of Pressure Probe.

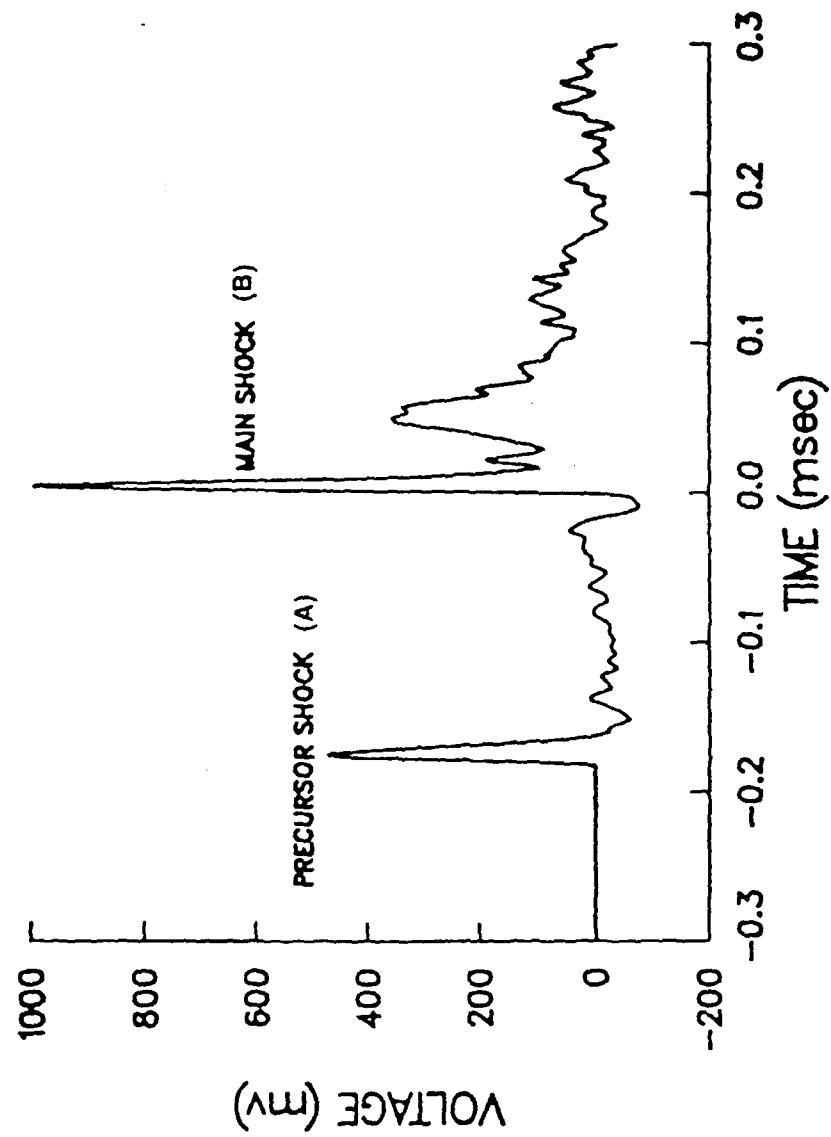


Figure 2. Typical 25-mm Muzzle Signature.



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~ 15 FT. BORE LENGTH  
AVERAGE PRESSURE

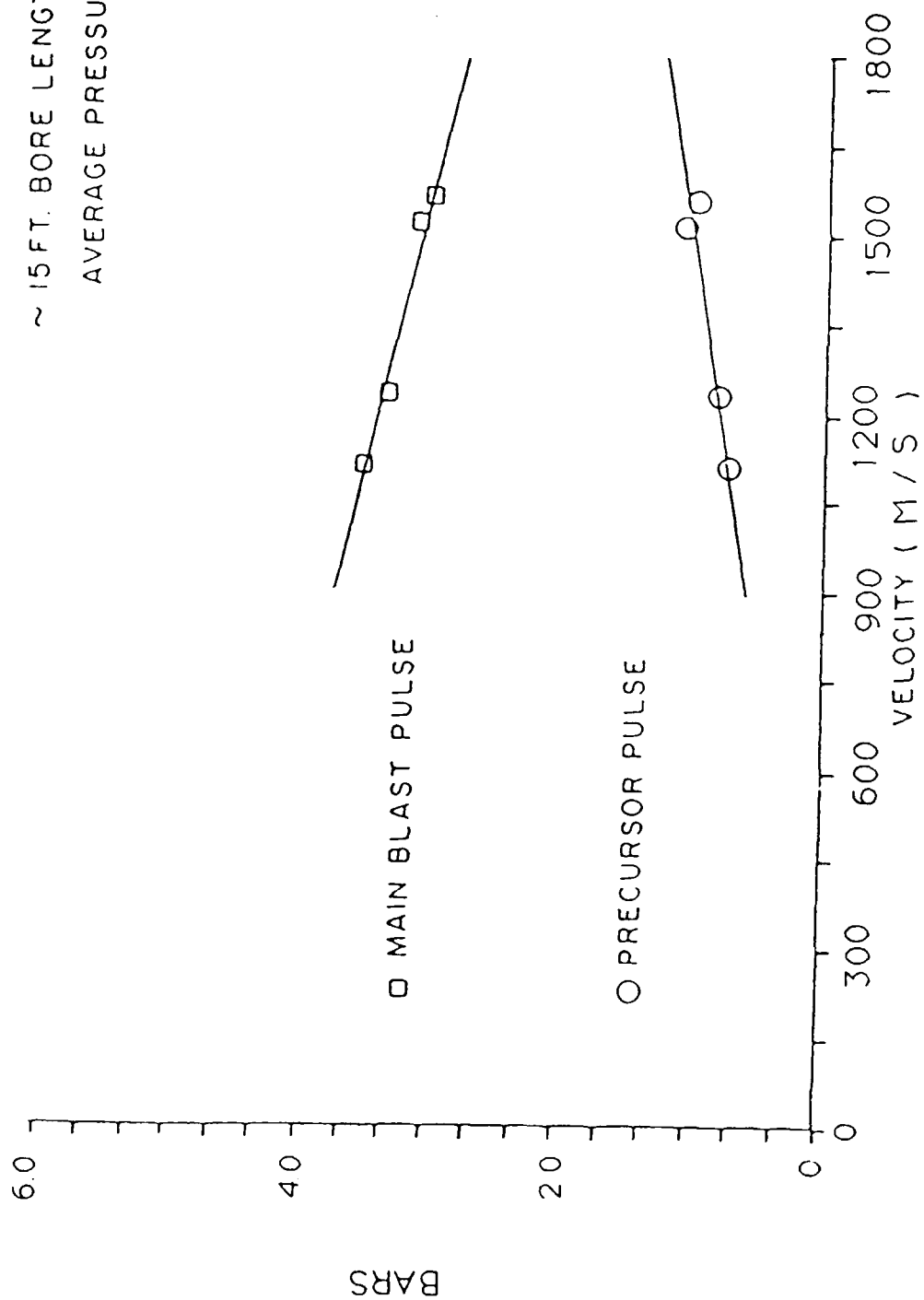


Figure 3 Pressure vs. Velocity for a 120-mm Weapon System.

TIME DIFFERENCE/TUBE LENGTH VS PROJECTILE VELOCITY

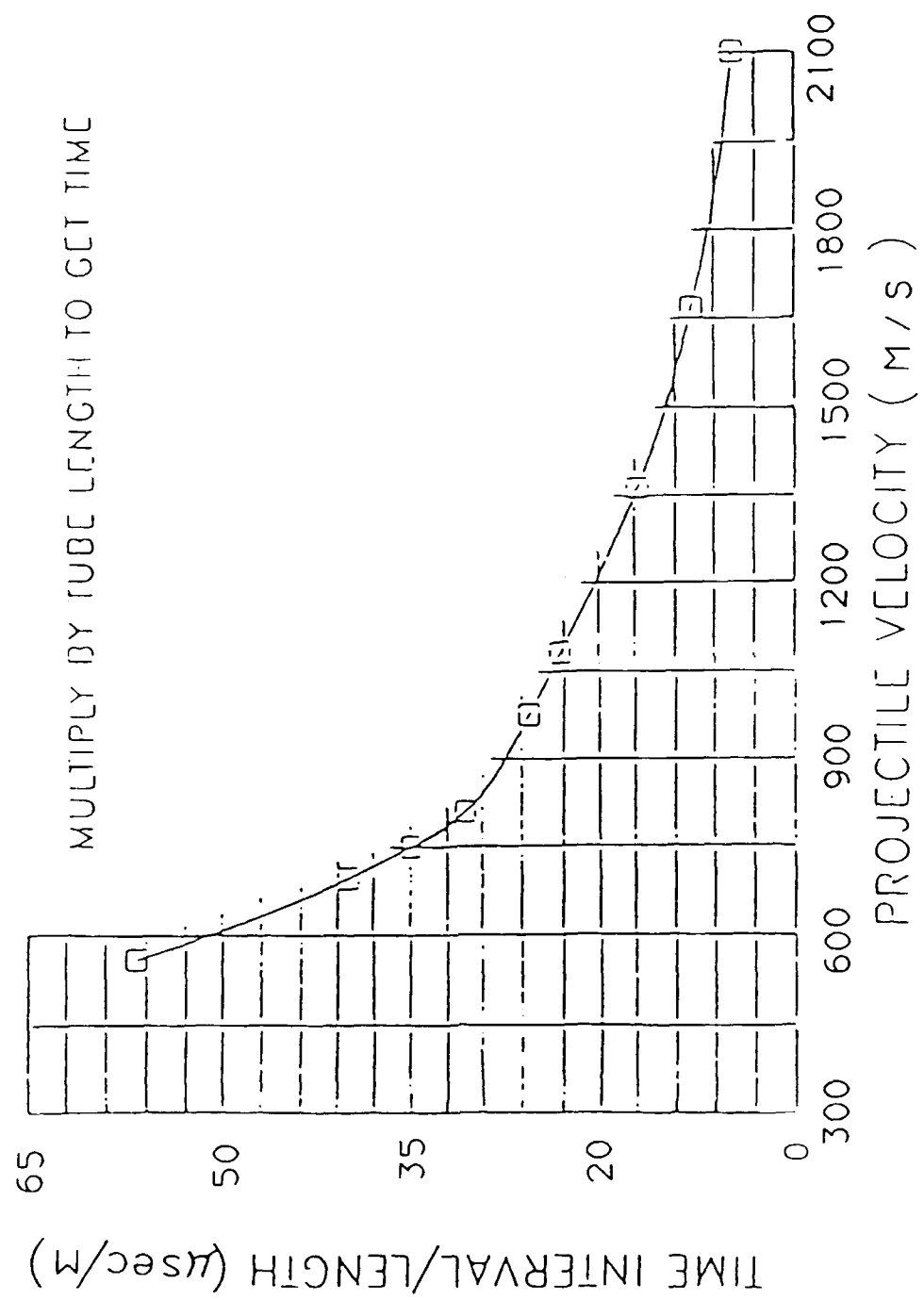


Figure 4 Pulse Separation Chart

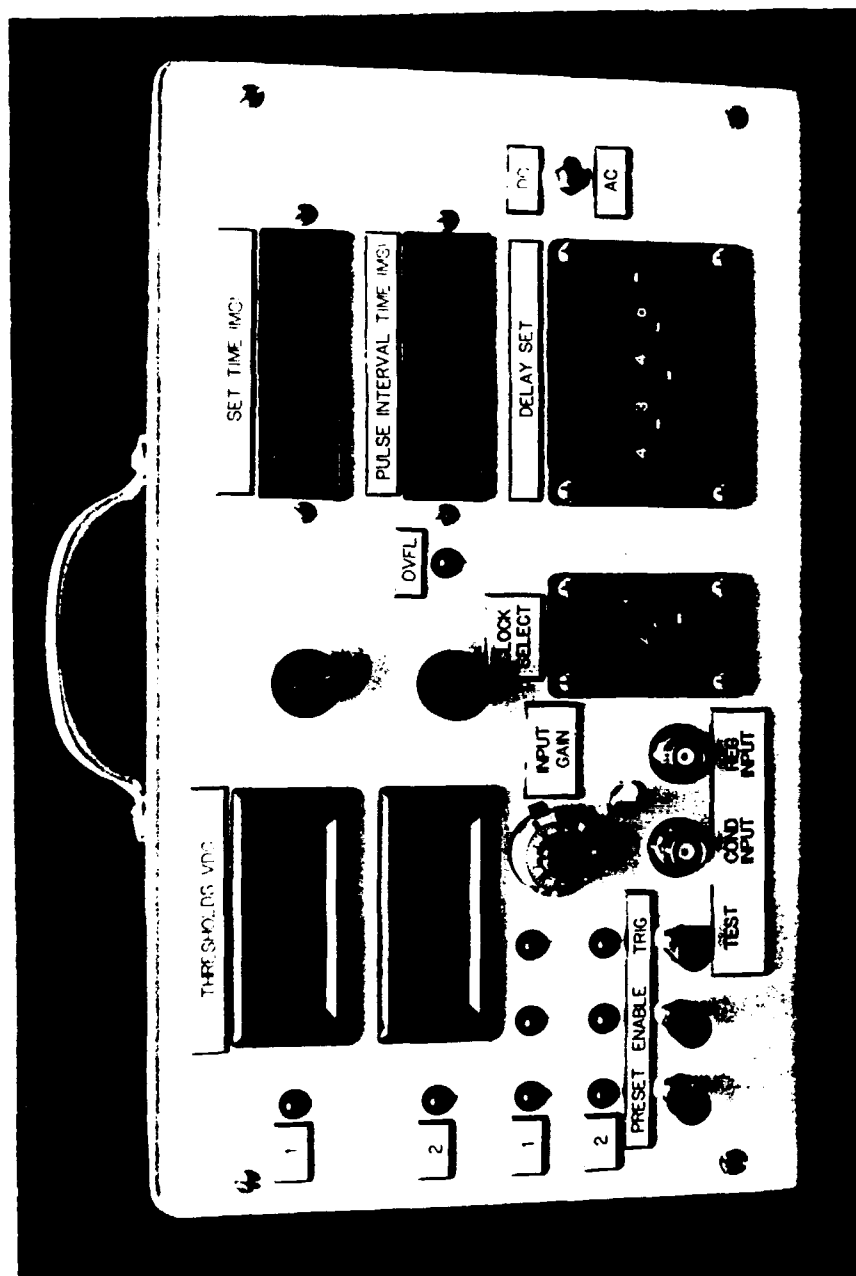


Figure 5. Time-Zero Box.



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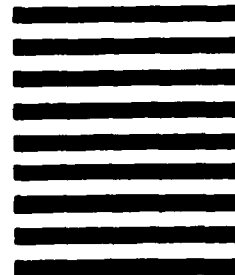
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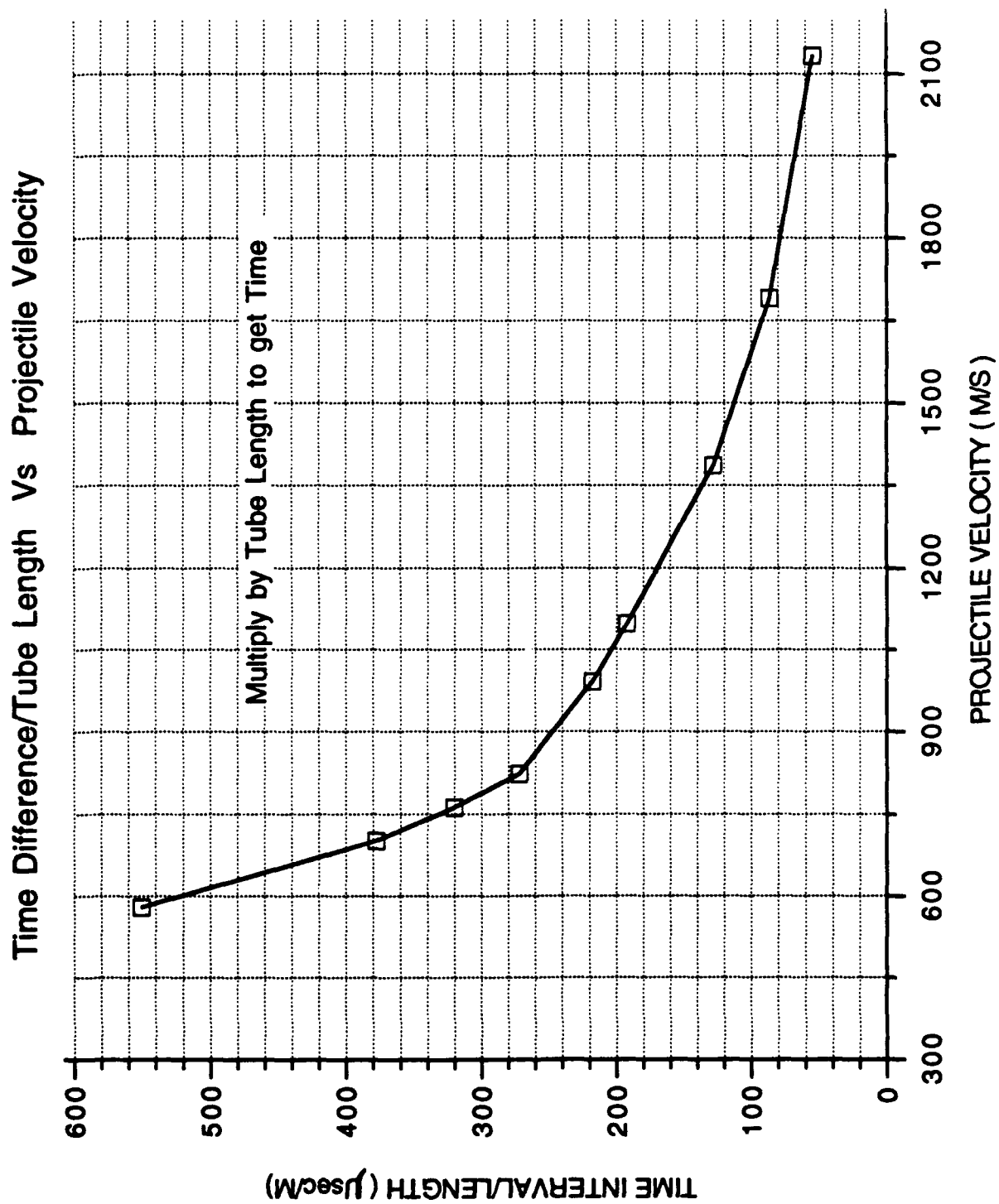


Figure 4 Pulse Separation Chart

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